Integrated Plant Disease Control

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Integrated plant disease control is discussed with specific reference to nurseries and hydroponic systems. Application of the fundamental principles of disease control, based on the disease triangle, is applied in designing disease management strategies for nurseries and hydroponic systems as models.

INTRODUCTION

Integrated disease control implies the principle of integrating different disease control measures in an overall, holistic strategy. A disease control strategy can be designed for any plant production/propagation system, be it a nursery, a hydroponic system, or open production system on a farm, regardless of the size of the operation. In the absence of such a strategy disease control often takes place as an ad hoc operation based on crisis measures. The benefits of an integrated disease control program are more efficient and cost effective disease management which is often based on prevention rather than cure.

In this paper, integrated disease control will be discussed with special emphasis on nurseries and hydroponic systems.

FUNDAMENTAL PRINCIPLES OF INTEGRATED PLANT DISEASE CONTROL

Any plant disease is based on three fundamental components — namely the host plant, the pathogen, and environmental conditions — which constitutes the disease triangle. For a disease to develop the plant must be susceptible, the pathogen must be virulent, and the environmental conditions must be conducive to disease development. Disease control can be achieved by influencing or manipulating any one, or any combination of the three components.

Integrated plant disease control is based on the premise of integrating various control measures in a synergistic way. The main aims of an integrated disease control program are: (1) eliminating or reducing initial inoculum, (2) reducing the effectiveness of initial inoculum, (3) increasing resistance of the host, (4) delaying onset of disease, and (5) slowing down disease development.

INTEGRATED DISEASE CONTROL IN THE NURSERY

The three greatest dangers in a nursery are: (1) infected seed, seedlings or propagation material,(2) infested irrigation water, and (3) infested growth medium.

The main components of a disease control strategy for nurseries fall into two categories namely preventative measures and curative measures. The following is by no means a complete list, but does cover the main aspects.

Preventative Measures.

Pathogen-Free Seed, Seedlings, and Propagation Material. Depending on the types of plants propagated, great care should be taken to ensure that disease-free mother material is used. Testing of the mother material in a plant pathology laboratory to confirm the absence of pathogens is essential, even in the absence of any visible symptoms of disease. A range of detection techniques exists for the various types of pathogens including viruses, fungi, and bacteria.

Pathogen-Free Irrigation Water. Pathogen-free irrigation water is imperative for any nursery. The nature of the water source and the quality of the water will dictate the measures required for water purification and sterilization. A substantial amount of literature exists on the different methods of water sterilization with their advantages and disadvantages (Mebalds et al., 1996; Mebalds et al., 1997). The irrigation water should be tested regularly by a plant pathology laboratory for the presence of pathogens to ensure sustained efficiency of the sterilization programme.

Pathogen Free Growth Medium. Various methods of media sterilization exist, of which heat sterilization is probably the most effective (Mulder, 1979). The most applicable method of sterilization will depend on the type of medium used. The use of pathogen-suppressive media based on bark mixes (Hoitink et al., 1991) is a viable alternative to total sterilization. Again, regular testing of the medium for the presence of pathogens is imperative.

Design and Lay-out of the Nursery. Disease prevention and phytosanitation should be a key factor in the design of a nursery. High risk areas such as the medium preparation area should be identified as a highly sterile area and isolated to prevent introduction of pathogens into that area. The concept of regulation of the direction of "traffic flow" from highly sterile to less sensitive areas should be implemented.

Application of Phytosanitary Measures Throughout the Nursery. These measures should involve integrated control measures aimed at eliminating or reducing pathogen inoculum. This would include chemical control measures such as use of surface sterilants and preventative fungicides as well as certain biological control measures. Cleaning and sterilizing implements, equipment and walkways should be a routine procedure. Entrances to the nursery should be equipped with a basin (foot bath) containing a sanitizing solution such as copper sulphate.

Manipulation of Environmental Conditions. In certain instances such as production of plants in greenhouses or tunnels, manipulation of environmental conditions such as temperature and humidity can affect the incidence of diseases. Proper management of irrigation is often an important factor in disease management. Irrigation frequencies can be manipulated to reduce the incidence of soilborne diseases. Overhead irrigation which wets the foliage often aggravates foliar diseases.

Chemical Control. Preventative (nonsystemic) fungicides are powerful tools which can be implemented in an integrated disease management program. In terms of pathogens developing resistance against chemicals, preventative fungicides have a lower risk than selective systemic fungicides.

Curative Measures.

Chemical Control. Curative measures in the nursery include the use of curative fungicides. Modern selective fungicides are high-risk compounds in terms of development of pathogen resistance. Resistance-prevention measures should therefore be implemented (Delp, 1980).

Manipulation of Environmental Conditions. It is often difficult to change environmental conditions. Some aspects such as irrigation frequency can be changed to suppress root diseases. In greenhouses, temperature and humidity can also be controlled to a degree.

INTEGRATED DISEASE CONTROL IN HYDROPONIC SYSTEMS

Hydroponic systems being dependent on a continuous supply of nutrients through the irrigation water, are particularly vulnerable to water-borne pathogens, such as *Pythium*, the causal organism of wilt and root rot. The three greatest dangers in a hydroponic system are infested irrigation water, infected seed or seedlings, and infested growth substrate. As is the case with nurseries, control measures for hydroponic systems also fall into two categories namely preventative measures and curative measures.

Preventative Measures.

Pathogen-Free Seed or Seedlings. Introducing infected seedlings into the system will immediately jeopardize the whole system, especially in the case of a water-borne pathogen such as *Pythium*. This pathogen is distributed through the system by means of mobile zoospores which move in water. Re-circulating systems are particularly vulnerable to the disease.

Sterilization of Irrigation Water. This aspect is again of primary importance, especially in re-circulating systems. The type of sterilization procedure (Mebalds et al., 1996) will depend on the requirements for the specific type of system used.

Sterilization of Growth Substrate. When a substrate such as gravel or perlite is re-used in a hydroponic system, sterilization of the substrate is essential. Although heat sterilization is very effective, it is often difficult to apply in practice, depending on the type of system. Various chemical sterilization procedures are being evaluated by the author at the University of Pretoria for their ability to eradicate pathogens from infested hydroponic substrates (unpublished data).

Frequent Monitoring for the Presence of Pathogens. Regular testing of the irrigation water for the presence of pathogens such as *Pythium* is of primary importance.

Disease Prevention Measures Included in the Design of the System. Components such as an effective water sterilization unit should be included in the design of the system as one of the key components. Other disease control measures such as phytosanitation, medium sterilization, etc. should be taken into account in the design of the system.

Curative Measures.

Chemical Control. Chemical control measures are still indispensable in most crop production systems. It is, however, essential to integrate chemical control with preventative measures in a disease management strategy. As with nurseries, ways of preventing development of resistance against fungicides should be implemented (Delp, 1980).

Manipulation of Environmental Conditions. Hydroponic systems in greenhouses or tunnels afford the opportunity of controlling environmental conditions such as temperature to a degree.

CONCLUSIONS

Plant disease control should never be conducted on a fragmented, ad hoc basis triggered by crisis situations, but rather on the basis of an overall (holistic) strategy of integrated control, developed according to the requirements of each individual production system.

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